Field Testing of the Experimental Wood Preservative N'N-naphtaloylhydroxylamine: Five and Eight Years Results

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ABSTRACT

Field trials were designed to evaluate the ability of the experimental wood preservative N'N-naphthaloylhydroxylamine (NHA) to inhibit fungal decay and termite damage at the USDA Harrison Experimental Forest (HEF) in Saucier, MS. Twenty replicate 19 x 19 x 457 mm (0.75 x 0.75 x 18 in.) southern yellow pine stakes and 10 replicate 19 x 19 x 76 mm (0.75 x 0.75 x 3 in.) blocks were pressure treated with three concentrations of aqueous NHA (0.f1, 0.5, and 1%). One percent CCA-C served as positive control. The smaller specimens were designed to favor termite attack by inserting the test specimen into untreated 38 x 89 mm (1.5 x 3.5 in.) pine feeder stakes slightly above the bround line. Feeder stakes were destroyed or dismantled after 5 years and the small blocks were rated visually. The longer stakes were evaluated annually for the first five years and then every other year until the eighth year. The standard 18" NHA-treated stakes kept pace with the CCA-treated stakes for the first five years and then rapidly decayed. The smaller specimens, after 5 years, showed similar results. Untreated controls and 0.1% NHA-treated blocks failed, while 1% NHA- and CCA-treated blocks were protected against termite feeding. The calcium precipitating agent NHA, has modest capacity to prevent fungal and termite damage, but the protective effect diminishes after five years in ground contact.

Keywords: CCA, NHA, subterranean termites, fungal decay, stake test

INTRODUCTION

Since the voluntary removal of chromated copper arsenate (CCA) from the housing market in residential applications in 2001, wood treatments have used copper as the main preservative. Although copper-based wood preservatives are effective at preventing damage from numerous decay fungi and insect species, there are still suboptimal aspects to using heavy metals in wood preservation, including the rising cost of copper, toxicity to aquatic organisms and potential for corrosion of metal fasteners and hardware. In a rapidly changing natural environment, there is always a necessity to explore, examine and test new preservative chemicals keeping in mind the views of the consuming public, evolving attitudes towards chemical preservatives, ecological impact and environmentally benign characteristics.

Preliminary tests on the calcium precipitating agent N'N-napthaloylhydroxylamine (NHA) were initiated in 1995. Laboratory tests based on AWPA D-1413 76 and AWPA E1-82 standards showed that at two concentrations of NHA (0.5% and 1.0%) fungal decay and termite damage to pine were significantly reduced (Green et al. 1997, 2001). The objective of the current experiments was to evaluate and confirm the positive laboratory results with stake tests under severe field conditions at HEF in Mississippi.

MATERIALS AND METHODS

Preservative Treatment

Twenty replicate southern yellow pine (SYP) stakes (19 x 19 x 457 mm (0.75 x 0.75 x 18 in.)) and 10 replicate 19 x 19 x 76 mm (0.75 x 0.75 x 3 in.) blocks were treated with 0.1, 0.5, 1% N'N-naphthaloylhydroxylamine (NHA), or 1% chromated copper arsenate Type C (CCA-C) with untreated SYP as a negative control. All treatments were conducted using a full-cell pressure process. The initial vacuum was maintained at -75 kPa (gauge) for 30 min; the pressure was maintained at 1.03 MPa for 1 hour. Each stake was weighed before and after treatment to determine solution uptake and allow calculation of uptake retention. All specimens were conditioned to a constant weight in a room maintained at 74°F (23°C) and 65% relative humidity.

Table 1. Average retention of full cell preservative treatments of termite blocks and stakes

Preservative Treatment	Active Ingredient (a.i.)	Retention			
		Blocks		Stakes	
		lb/ft^3	kg/m^3	lb/ft^3	kg/m^3
Control	0%	n/a	n/a	n/a	n/a
CCA	1%	0.42 ± 0.01	6.72 ± 0.16	0.42 ± 0.02	6.70 ± 0.25
NHA	1%	0.40 ± 0.02	6.40 ± 0.32	0.41 ± 0.02	6.48 ± 0.28
NHA	0.5%	0.20 ± 0.01	3.20 ± 0.16	0.21 ± 0.01	3.32 ± 0.11
NHA	0.1%	0.04±0.00	0.64±0.02	0.04 ± 0.00	0.64 ± 0.03

Specimen Installation and Inspection

Stakes were installed in a forested plot within the Harrison Experimental Forest (approx. 15 mi. N of Gulfport-Biloxi, MS). This location is within Deterioration Zone 5 (severe deterioration hazard, AWPA 2006). Stakes were buried vertically to half their length and placed randomly within the plot in rows with 305 mm spacing between stakes and 915 mm between rows. The stakes were installed in June 1997 and were inspected at 1, 2, 3, 4, 5, 7 and 9 years after installation. Inspections consisted of removing the stake from the ground, lightly scraping off excess dirt, and giving each sample a visual rating for decay and/or termite damage according to the scale described in Table 2 (AWPA Standard E7-07 2007).

Table 2. Rating system used for all plots[a] (modified from AWPA 2007)

Rating	Decay Rating Description	Termite Rating Description
10	Sound. Suspicion of decay permitted	Sound. 1 to 2 small nibbles permitted
9	Trace decay to 3% of cross section	Slight evidence of feeding to 3% of cross section
8	Decay from 3% to 10% of cross section	Attack from 3% to 10% of cross section
7	Decay from 10% to 30% of cross section	Attack from 10% to 30% of cross section
6	Decay from 30% to 50% of cross section	Attack from 30% to 50% of cross section
4	Decay from 50% to 75% of cross section	Attack from 50% to 75% of cross section
0	Failure	Failure

[a] The additional rating of "9.5" added to AWPA Standard E7 in 2007 was not used in these plots.

Smaller specimens, 19 x 19 x 76 mm (0.75 x 0.75 x 3in.), were designed to favor termite attack by inserting the test specimen into untreated 38 x 89 mm feeder stakes slightly (50-76 mm (2-3 in.) above the ground line similar to methods by Lebow et al. (2006) and Amburgey et al. (1993) (Figure 1). Each assembled feeder stake and test specimen was then covered with a metal cap to protect it from rainfall. Pine feeder stakes were dismantled after 5 years and the small blocks were rated visually.

RESULTS AND DISCUSSION

Decay and termite ratings for the long, 457 mm (18 in.) stakes are shown in Figures 1 and 2. Control and 0.1% NHA-treated stakes showed no inhibition of termites or decay fungi. The 1% NHA-treated stakes kept pace with the CCA-treated stakes for the first five years and then rapidly decayed. The 0.5% NHA-treated stakes fell somewhere in between the two. More than likely, leaching of NHA by rainfall was the primary reason for the failure of the NHA-treated sticks in the field. Although NHA is relatively leach resistant in the presence of precipitating cations such as the calcium found in tap water or seawater, greater leaching can occur in deionized water (Kartal et al. 2002). Also, when distilled water was used to irrigate fungal cellars in a soft-rot test, there was no difference in decay resistance between the NHA-treated and control sticks (Crawford and Green 1999). Other possible explanations are biotransformation of the NHA ring structures into less toxic moieties by bacteria or fungi, or gradual tolerance to the NHA over time by decay fungi, which seemed to do the most damage to treated stakes (Arango et al. 2009).

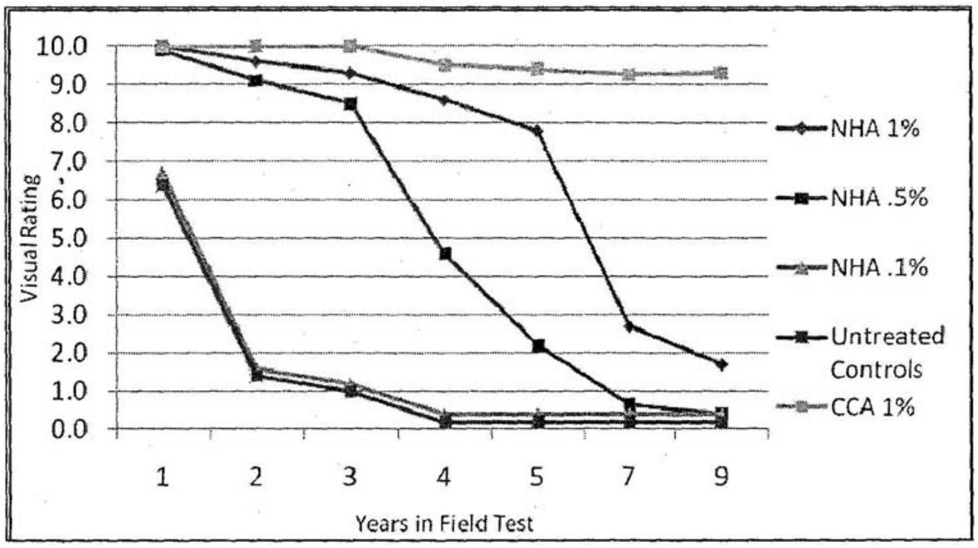

Figure 1: Average decay rating of 457 mm (18 in.) stakes

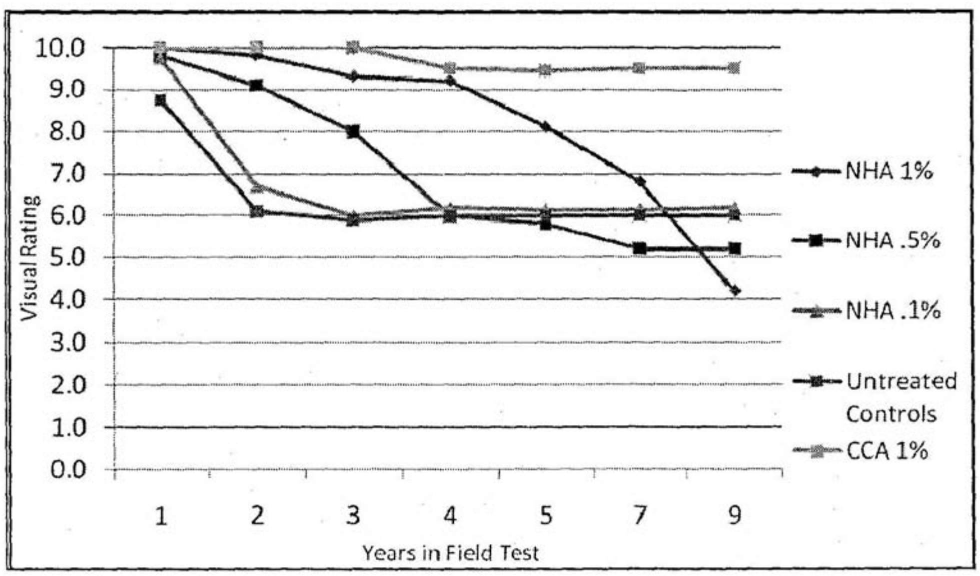

Figure 2: Average termite damage rating of 457 mm (18 in.) stakes

The smaller 76 mm (3 in.) test specimens were protected to a greater degree inside the feeder pine two-by-fours from leaching during the five-year test. Both CCA and 1% NHA still had average ratings of 10 and 9, respectively, at the conclusion of the test (Table 3). Control blocks and those treated with 0.1% NHA showed significant feeding damage from termites (Figure 3).

Table 3. Average visual termite rating of 76 mm (3 in.) stakes after 5 years in the field

Active Ingredient (ai.)	Percent a.i.	Average Visual Termite Rating
Control	0%	1.2
CCA	1%	10
NHA	1%	9
NHA	0.5%	8.1
NHA	0.1%	3.5

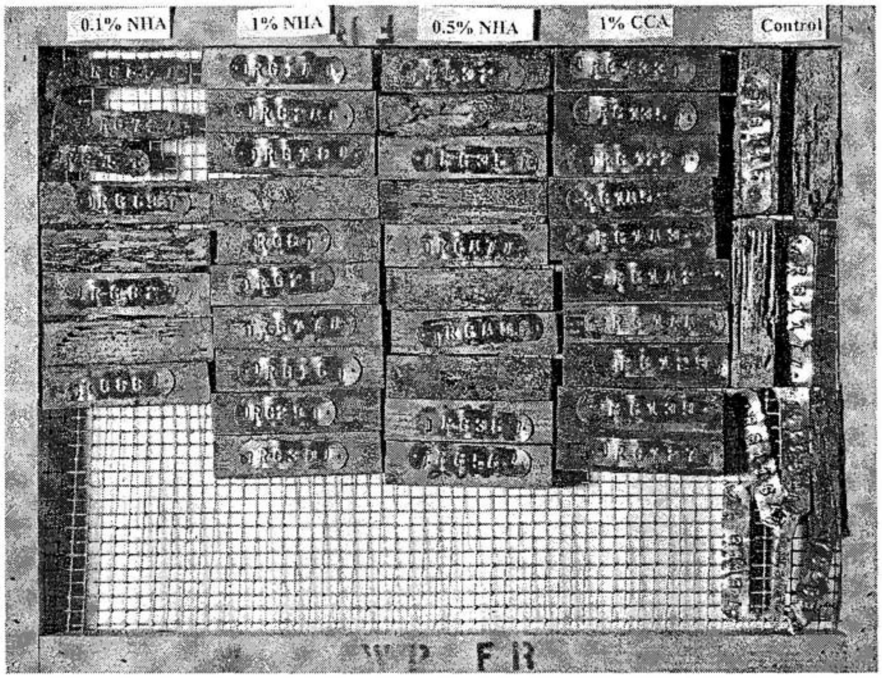

Figure 3: NHA-, CCA-treated and control 76 mm (3 in.) test specimens after 5-year-termite exposure in the field

Overall, these field tests indicate that although NHA provides substantial initial protection against decay in ground-contact, leaching or some other mechanism of degradation lessens this protection over time. Termite resistance of NHA-treated wood remained high when the specimens were partially protected from precipitation. Although NHA may not be suitable as a stand-alone ground-contact wood preservative, it does have other applications. It may be added as a co-biocide in a multi-component wood preservative treatment. Unrelated research has shown that NHA (at 500 ppm) is an effective termite attractant and toxicant, and it was patented and licensed for use in termite baiting systems in 2004 (Rojas et al. 2004).

CONCLUSIONS

The presence of 0.5 and 1.0% NHA in the treated stakes and wood blocks did provide improved decay and termite resistance relative to the untreated controls. The 1% NHA-treated blocks also provided fairly effective protection against decay for stakes exposed in Mississippi for the first 5 years, after which protection rapidly declined to that observed in untreated controls most likely because of leaching of the NHA preservative. Interestingly, in the 76 mm (3 in.) wood block test, all feeder stakes had termites present at the five-year time period. Blocks treated with 0.5 and 1% NHA showed substantial protection from termite damage, comparable to the CCA-treated blocks. The protection afforded by the feeder stake may have limited attack by decay fungi and leaching of the preservative. As in the case with borates, it may be that NHA treated wood is best used in partially protected above ground exposures where it is only intermittently exposed to precipitation or other sources of water.

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